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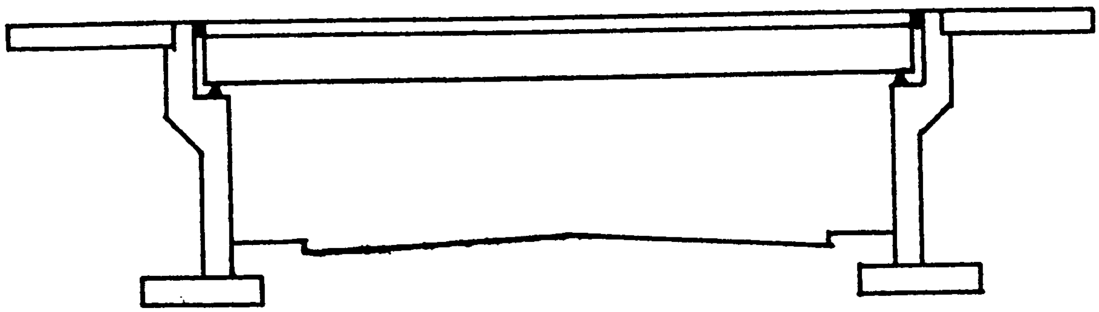
12.1 GENERAL

Abutments are used at the ends of bridges to retain the embankment and carry the vertical and horizontal loads from the superstructure. They are designed as retaining walls as well as piers and must be stable against overturning and sliding. Abutment foundations are designed to prevent differential settlement and excessive lateral movements.

Many types of abutments can be satisfactorily utilized for a particular bridge site. Economics is usually the prime factor in selecting the type of abutment to be used. For river or stream crossings the minimum required channel area and section are considered. For highway overpasses minimum horizontal clearances and sight-distances are maintained. An abutment built on or on top of a slope is less likely to become a collision obstacle than one on the bottom and is more desirable from a safety standpoint. Aesthetics is a factor when selecting an abutment type.

12.2 ABUTMENT TYPES

(1) Full Retaining



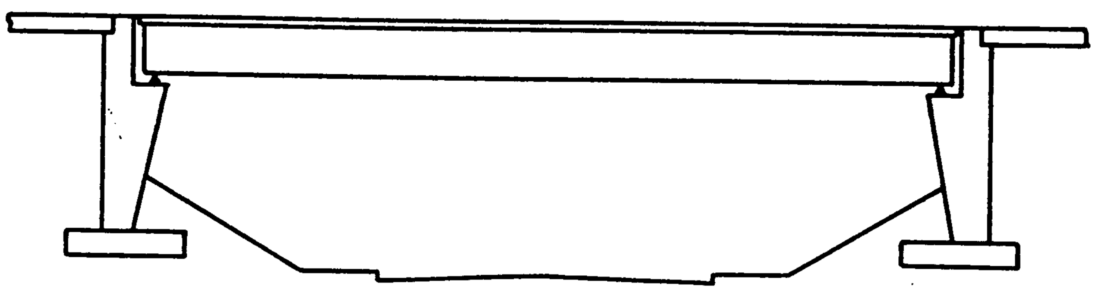
A full retaining abutment is built at the bottom of the abutment slope and must retain the entire roadway embankment. This type of abutment is the most costly. It may be desirable where right of way is critical. By reducing the span length and superstructure cost, the total structure cost may be reduced in some cases. Rigid frame structures use a full retaining abutment poured monolithic with the superstructure. If both abutments are connected by fixed bearings to the superstructure (as in rigid frames) the abutment wings are joined to the body by a mortised expansion joint. For a non-skewed abutment this enables the body to rotate about its base and allow for superstructure contraction and expansion due to temperature and shrinkage, assuming the rotation is possible. This differential settlement is not uncommon due to the different loads on the two foundations.

An objectionable feature of full retaining abutments is the difficulty associated with placing and compacting material against the body and between the wing walls. It is possible that this type of abutment may be shoved out of vertical alignment if heavy equipment is permitted to work near the walls. The placement of the embankment after abutment construction may cause foundation settlement. For these reasons, as much of the roadway embankment as practical should be in place before starting abutment construction. Backfilling is prohibited until the superstructure is in place.

Other disadvantages of full retaining abutments are:

1. Minimum horizontal clearance
2. Minimum sight distance
3. Collision hazard
4. Settlement

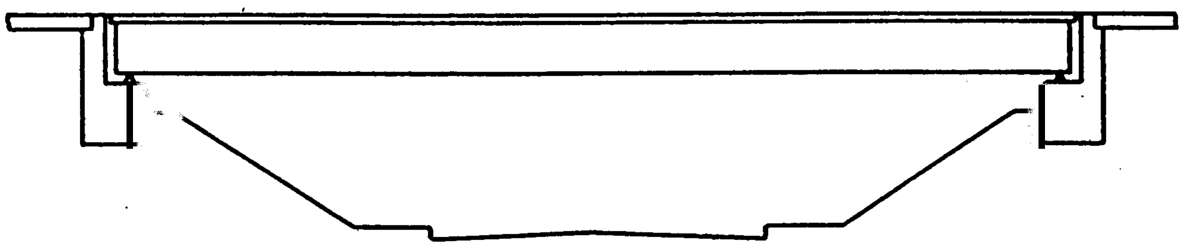
(2) Semi-Retaining



The semi-retaining abutment (Type A4) is built somewhere between the bottom and top of the roadway embankment. It provides more horizontal clearance and sight distance than a full retaining abutment. Located on the embankment slope it becomes less of a collision hazard for a vehicle out of control.

The discussion about full retaining abutments generally applies to semi-retaining types. They are used primarily in highway-highway crossings as a substitute for a shoulder pier and sill abutment. These abutments generally are designed with a fixed base allowing wing walls to be rigidly attached to the abutment body. Wings and body are usually poured monolithically.

(3) Sill



The sill abutment (Type A1 and A3) is constructed at the top of the slope after the roadway embankment is close to final grade. Many consider that this abutment offers the best means of avoiding most of the problems that cause rough approach pavements. It eliminates the difficulties of obtaining adequate compaction adjacent to the relatively high walls of closed abutments. A berm is constructed at the front of the body as the approach embankment may settle by forcing up or bulging up the slope in front of the abutment body. The weight of the berm helps prevent this.

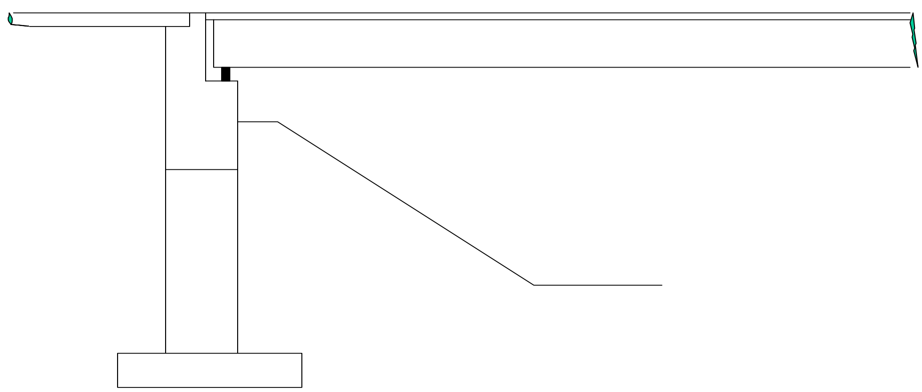
Sill abutments are the least expensive and easiest to construct. This type of abutment results in a higher superstructure cost so the overall cost of the structure should be evaluated with other alternatives.

The A1 abutment with a Fixed Seat is used for shallow superstructures where no wing piles are required. This minimizes cracking between the body wall and wings.

The A1 abutment with a Semi-Expansion Seat is used when wing piles are required for this abutment type. The allowance for superstructure movement reduces the potential cracking between the wings and body.

The Type A1 abutment has a height of 5 feet (1.5 meters) shown on the Standard. The total height has been extended to 8 feet (2.4 meters) without any adverse effects in the field. It is felt that this is about the maximum height to use. The parallel to abutment centerline wings, elephant ear wings, as shown on Standard 12.7 should be detailed on most A1 abutments. This wing type is preferred because it allows the abutment to be more flexible and compaction of fill is much easier and therefore more stable. However, parallel wings are still required at stream crossings where highwater may be a problem. 45° wings while not preferred, may be used for local bridges on stream crossings.

(4) Spill-Through or Open



This type of abutment is mostly used where an additional span is to be added to the bridge at a later date. It may also be used to satisfy some unique construction problem. It is situated on columns or stems that extend upward from the natural ground. It is simply a pier being used as an abutment.

It is very difficult to properly compact the embankment materials that must be placed around the columns and under the abutment cap. Early settlement and erosion are problems frequently encountered with this type of abutment.

If the abutment is to be used as a future pier, it is important that the wings and backwall be designed for easy removal. Construction joints are separated by felt or other material. Bar steel is not extended through the joints. Bolts with threaded inserts are used to carry tension stresses across joints.

(5) Pile Encased

Pile encased abutments (Type A5) should only be used where documented cost data shows them to be more economical than sill abutments due to conditions at the site. Studies show that using sill abutments with longer bridges under most conditions have significant cost advantages over using the A5 abutments. A5 abutments may require additional erosion control measures that increase construction cost.

| Pile encased abutment wall height is limited to a maximum of 10 feet since more wall height along with the superstructure will increase soil pressure resulting in uneconomical pile design due to there size or spacing requirements. Reinforcement in the abutment body was | designed based on 2 feet of live load surcharge and soil pressure on the back wall. Pile encased abutments are limited to a maximum skew of 15 and 30 degrees with girder superstructures and slab spans respectively in order to limit damage due to thermal expansion or contraction of the superstructure. Also, wing skew angles are limited to 45 degrees to prevent cracking between the abutment body and wings.

(6) Special Designs

Many different styles and variations of standard abutment types can be designed. The reasons for their special designs may be based on aesthetics, unique soil, or structural problems.

12.3 TYPES OF ABUTMENT SUPPORT

(1) Piles or Drilled Shaft

The majority of abutments built are supported on piles to prevent abutment settlement. Most bridge approach embankments are constructed of fill material that usually experiences some settlement which may take place for several years. This settlement may be the result of changes in the embankment or the original foundation under the embankment. By driving piles through the fill embankment and well into original ground the abutments usually do not settle with the embankment. A settling embankment may become supported by the abutment piles by friction between piles and fill material. The added load to friction piles should be considered and whether preboring is required.

Generally, it is not necessary to prebore non-displacement piles for any fill depths or displacement piles for fill depths under 15 feet below the bottom of footing. However, for some problem soils this may not apply. See the Soils Report to determine if preboring is required. The Special Provisions give preboring requirements. Reduce the capacity of friction piles by 500 pounds per foot if fill material is more than 15 feet below the bottom of the footing. Battered piles may cause more of a problem than vertical piles and are given special consideration. Fill embankments frequently shift laterally as well as vertically. A complete foundation site investigation and information on fill material is a pre-requisite for successful pile design. Piles placed in prebored holes cored into rock do not require driving. The full design loading can be used if the hole is of adequate size to prevent pile hangups and allow filling with concrete.

Piles in abutments are subjected to lateral loads. The allowable lateral load on a pile is usually determined from an acceptable level of lateral displacement and not the ultimate load that causes a stress failure in the pile. The allowable lateral load on a pile may be more dependent on the material that the pile is driven into than on the type of pile. See Chapter 11 for a more thorough discussion on piles and allowable pile loads.

(2) Spread Footings

Generally, abutments on spread footings are used only in cut sections where the original soil can sustain reasonable pressures without excessive settlement. The allowable soil pressure is determined by the Geotechnical Section.

With improved procedure and better control of embankment construction spread footings can be used successfully on fill material. It is important that construction be timed to permit the foundation material to consolidate before the spread footings are constructed. An advantage of spread footings is that the differential settlement between approach fills and abutments is minimized.

The use of spread footings is given more consideration for simple span bridges than for continuous spans. For continuous spans under special conditions, the superstructure is designed to accept small amounts of settlement, if they occur. Drainage for abutments on spread footings can be very critical. In general, pile footings are preferred.

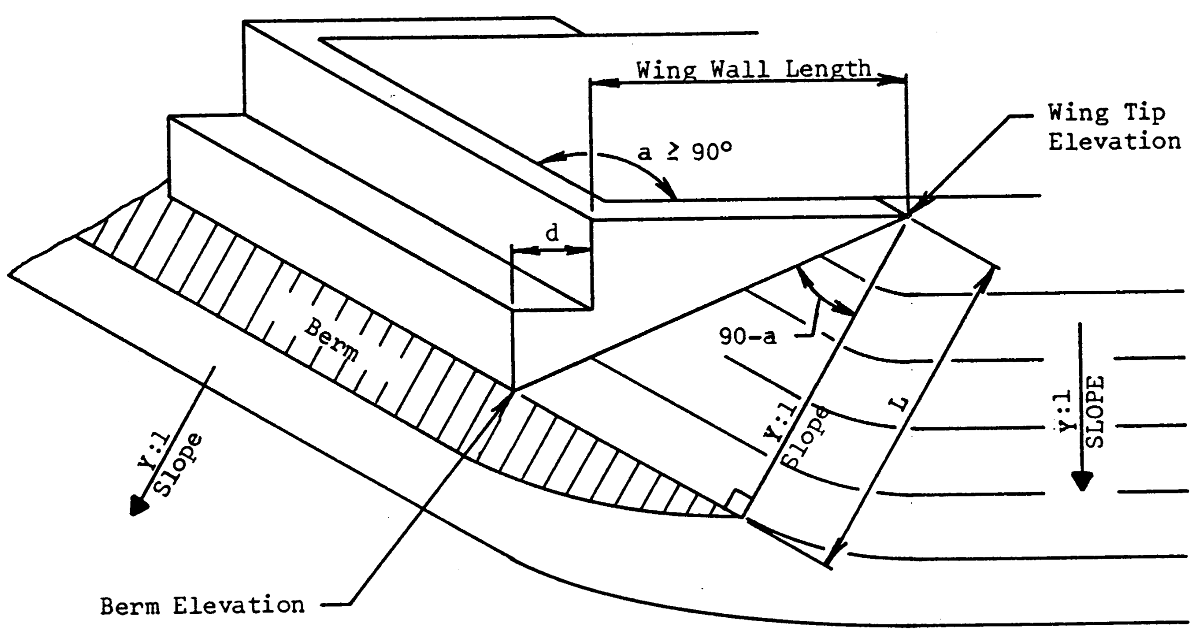
Lateral forces on the abutments are resisted by passive earth pressure and friction between soil and concrete. A shear key adds additional area on which passive earth pressure can act. A berm in front of the abutment may be necessary to prevent a shear failure in the soil along the slope.

12.4 ABUTMENT WING WALLS

(1) Wing Wall Length

The wing walls are long enough to retain the roadway embankment based on the required roadway slopes. They are usually extended back parallel to the centerline of the roadway. A slope greater than 2:1 is not used. Generally a slope of 2:1 is used. (See "Y" in sketches). Wing wall lengths are detailed in 6 inch (150 mm) increments. When setting length, be sure the theoretical slope of the earth does not fall above the bridge seat elevation at the corner.

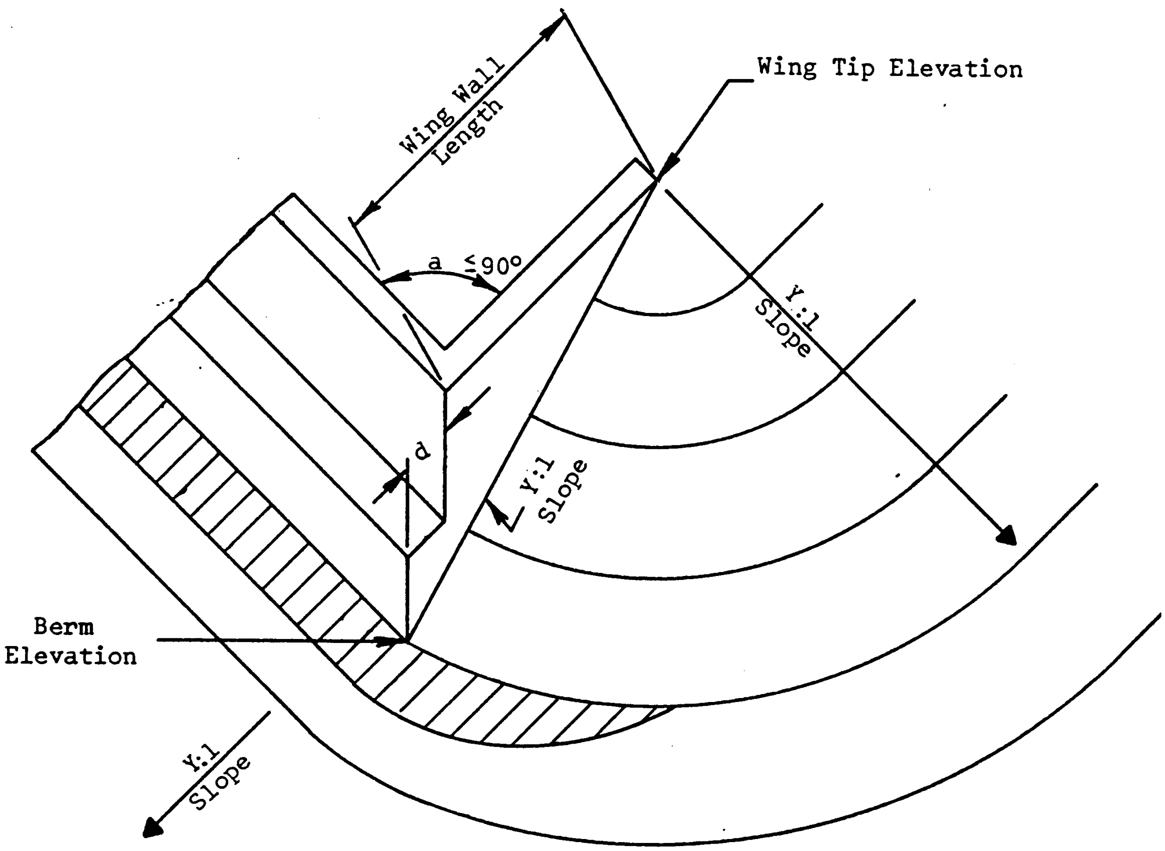
A. Calculation of Length when Wings are Parallel to Roadway:



For wing angle (a) at 90° or greater

L = (wing tip elevation - berm elevation) x Y

Wing Wall Length = L/cos(90-a)-d



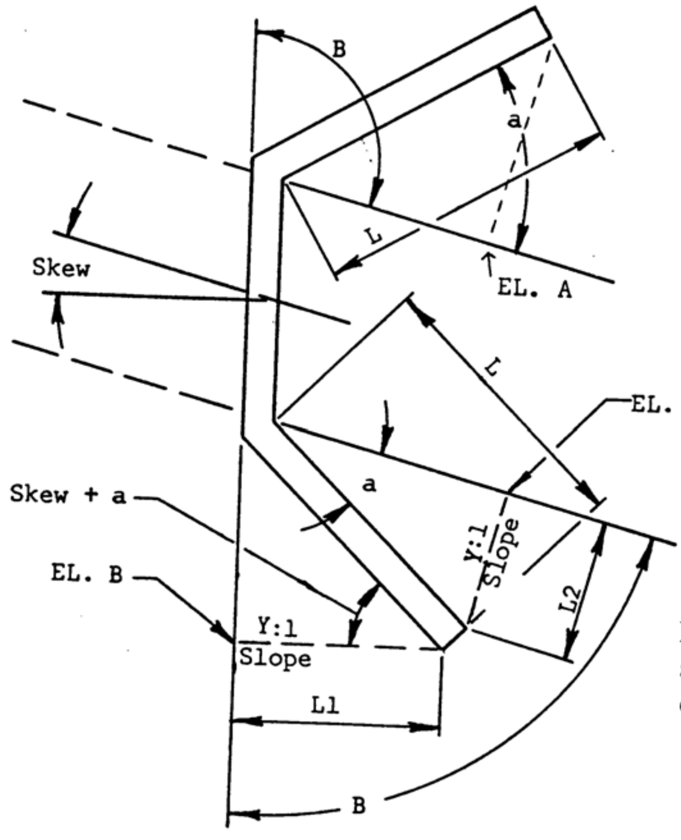
For wing angle (a) at 90° or less

Wing Wall Length = (wing tip elevation-berm elevation) x Y – d

B. Calculation of wing wall length when wings are not parallel to roadway and slopes are equal.

For B greater than 90°

L = Y x (EL.A - EL.B)/ (COS(a-SKEW) + SIN a)



EL. A is assumed for computation purposes, and is checked after wing length is determined.

For B less than 90°

L1 + L2 =(EL.A-EL.B) x Y

COS (SKEW + a) = L1/L

SIN a = L2/L

L = Y x (EL.A - EL.B)/
(COS(SKEW + a) + SIN a)

(2) Wing Wall Loads

| Wing walls are designed as Retaining Walls. See Chapter 14.

| The parapet wall on top of the wing is designed to resist railing loading but it is not necessary that these loads be applied to the wing walls. These loads are dynamic or impact loads and are absorbed by the mass of the wing wall and if necessary by passive earth pressure.

The forces produced by the active earth pressure are resisted by the wing piles and the abutment body. Passive earth pressure resistance generally is not utilized because there is a possibility the approach fill slopes may slide laterally away from the wings. This may seem like a conservative assumption but is justified due to the highly unpredictable forces a wing may experience.

Wing walls without special footings that are poured monolithic with the abutment body are subjected to a bending moment, shear force, and torsion force. The primary force is the bending moment. Torsion is usually neglected. For an example of a design including torsion see "Torsion of Structural Concrete", A.C.I. publication SP-18, page 483.

The bending moment induced in the cantilevered wing wall by active earth pressure is reduced by the expected lateral resistance of the wing pile group times the distance to the section being investigated. This lateral pile resistance is increased by using battered piles. Individual piles offer little lateral resistance because of small wing deflections. See Chapter 11 for allowable lateral loads on piles.

(3) Wing Wall Parapets

Steel plate beam guard is used at bridge approaches and is attached to the wing wall parapets. This helps in preventing vehicles from colliding directly into the end of the parapet.

A vehicle striking a guard rail may produce a high-tension force in the guard rail. It is important that sufficient longitudinal parapet steel be provided to carry this force. If the concrete in the parapet is demolished, the longitudinal parapet steel continues to act as a cable guard rail if it remains attached to the steel plate beam guard.

12.5 ABUTMENT DEPTHS, EXCAVATION AND CONSTRUCTION

(1) Abutment Depths

The required depth of the abutment footing to prevent frost damage depends on the amount of water in the foundation material. Frost damage works in two directions. First, ice lenses form in the soil, heaving it upward. These lenses grow by absorbing additional water from below the frost line. Silts are susceptible to heaves. Well-drained sands and dense clays generally do not heave. Second, the direction of frost action is downward. The ice lenses thaw from the top down, causing a layer of water to be trapped near the surface. This water emulsifies the soil, permitting it to flow out from under the footing.

Sill and semi-retaining abutments are constructed on slopes which remain relatively moisture free. Sill abutments have been constructed in all parts of Wisconsin with footings only 2.5 feet below ground and have experienced no frost heave problems.

Full retaining abutments are constructed on the bottom of embankment slopes and are more likely to have their footings on a soil of high moisture content. For this reason full retaining abutments have their footings below the level of maximum frost penetration. Maximum frost penetration varies from 4 feet in the southeastern part of Wisconsin to 6 feet in the northwestern corner.

(2) Abutment Excavation

Abutment excavation is referred to as "Excavation for Structures Bridges". It is measured as a unit for each specific bridge and is paid for at the contract lump sum price.

When a new bridge is constructed, a new roadway approaching the bridge is generally also constructed. Since the roadway contractor and bridge contractor are not necessarily the same party, the limits of excavation to be performed by each are specified. The roadway contractor cuts or fills earth to the upper limits of structural excavation as specified on the bridge plans or in the standard specifications book for road and bridge construction. If the bridge contractor does his work before the roadway contractor or there is no roadway contract, the upper limit of structural excavation is the existing ground line. For sill abutments the upper limit is specified in the Standard Specifications and need not be shown on the abutment plans.

For semi retaining and full retaining abutments the upper limits are shown on the abutment plans. If a cut condition exists the upper limit is usually the subgrade elevation and the top surface of the embankment slope (bottom of slope protection). Earth above these limits is removed by the roadway contractor. A semi-retaining or full retaining abutment placed on fill is considered as a unique problem by the design engineer and limits of Excavation are set accordingly. Construction sequence and type of fill material are considered when setting excavation limits. Slopes greater than 1.5 to 1 vertical are difficult to construct and generally are not specified. It is sometimes advantageous to have the roadway contractor place extra fill that later must be excavated by the bridge contractor because the overburden aids in compaction and reduces later settlement.

Lateral limits of excavation are not defined in the Standard Specifications. The contractor will excavate whatever is necessary for the placement of the forms.

(3) Abutment Construction

Generally, the abutment body is located above the normal water. Refer to the Specifications or Special Provisions where part of the abutment body is below normal water.

12.6 ABUTMENT DRAINAGE AND BACKFILL

(1) Abutment Drainage

Abutment drainage is necessary to prevent hydrostatic pressure and frost pressure. Hydrostatic pressure, soil and water included, can amount to an equivalent fluid pressure of 85 pcf. Frost action, which can occur in silty backfill, may result in extremely high pressures. On high abutments these pressures will produce a tremendous force which could result in structural damage or abutment movement.

To prevent these additional pressures on abutments it is necessary to drain away whatever water accumulates behind the body and wings. This is accomplished by using a pervious granular fill on the inside face of the abutment. Pipe underdrains will be necessary to drain the fill if it rests upon an impervious soil or rock.

For rehab structures, provide plan details to replace inadequate underdrain systems.

Most of central and northern Wisconsin has a native sandy soil which is quite pervious and it is not necessary to call for a special granular backfill. Southern and eastern Wisconsin have more clay type soils which generally are impervious. Soil borings at abutments will give some indication of the permeability of the underlying soils.

The following factors are considered by the designer in determining if granular backfill and/or pipe underdrains should be called for:

(1) Perviousness or drainability of the material at the bottom of the footing. Pipe underdrains are not needed on native sandy soil or when abutments are placed behind MSE walls due to the pervious fill for those walls.

(2) Type of material available within the right-of-way for the construction of the roadway. If pervious material is available it will be used for backfilling the inside of the abutments. Obtain information about available material from the district soils section if not known.

(3) Considerations for abutment heights. Past experience indicates that sill abutments are not capable of withstanding hydrostatic pressure on their full height without leaking.

Semi-and full retaining abutments generally will be overstressed or may slide if subject to large hydrostatic or frost pressures.

Where it is necessary to drain the backfill material with pipe underdrains, 6 inch corrugated metal pipe is recommended. Perforated pipe is used behind the abutment and unperforated is used outside the abutment to drain the water away. The best elevation at which to place the pipe underdrains is at the same elevation as the bottom of the footing. However, if it is not possible to discharge the water to a lower elevation, the pipe underdrains should be placed higher.

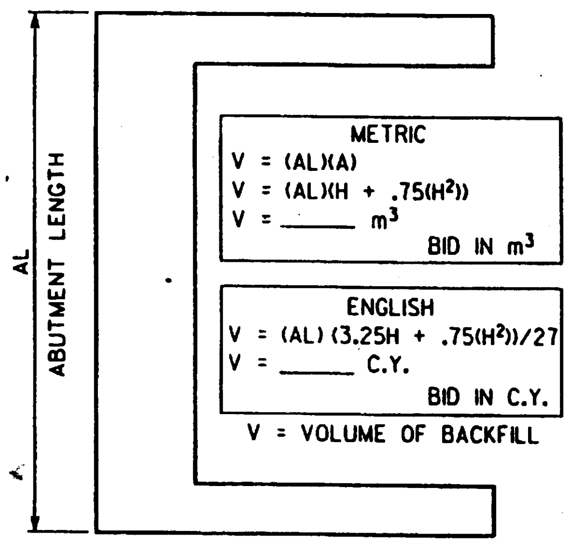
In general, less unperforated pipe outside the abutment is required when the perforated pipe behind the abutment is placed at higher elevations. On sill abutments perforated pipe underdrains can be located near the elevation of the bearing seats. At this elevation, it is much easier to discharge the water from the underdrains. Some pipe underdrains have been installed high in order that they can be extended directly through the wing walls and discharge water above the side slopes.

Pipe underdrains and weepholes may discharge water during freezing temperatures. In urban areas this may create a problem due to the accumulation of flow and ice on sidewalks.

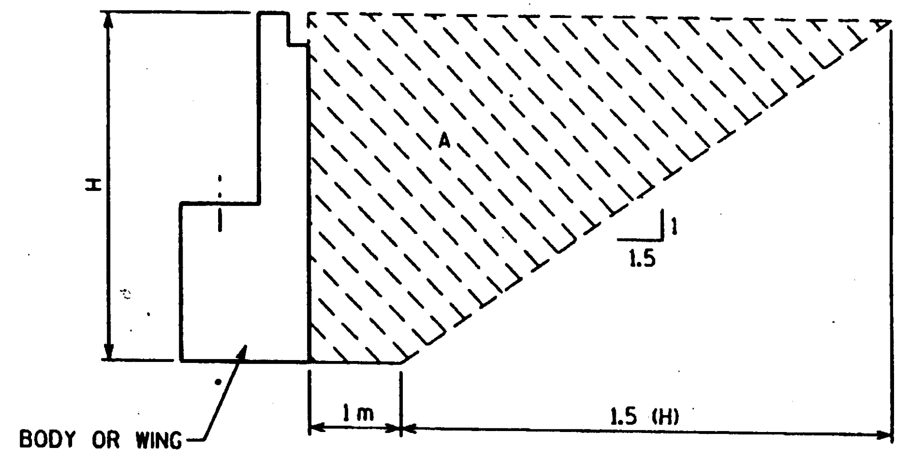
(2) Abutment Backfill Material

To insure adequate drainage behind full or semi retaining abutments, the District designer needs to specify pipe underdrains and Backfill Granular - Grade 1 or a material meeting the requirements of fine aggregates for concrete masonry. For bridges with sill abutments, Backfill Structure may be specified if the designer in the field feels that drainage behind the abutment is not an issue. The designer in the field needs to determine if the in situ material meets the requirements of Backfill Structure when determining quantities.

When Backfill Granular or Structure is specified, the limits for calculating the material quantity are as shown on the following sketch. This sketch is <u>not</u> to be shown on the contract plans.



ABUTMENT PLAN



A = SECTION OF STRUCTURE BACKFILL

WING ELEVATION

METRIC

$A = 1\,(H) + .5\,(H) \times 1.5\,(H)$

$A = H + .75\,(H^2)$

ENGLISH

$A = 3.25\,(H) + .5(H)(1.5H) = 3.25H + .75(H^2)$

BACKFILL GRANULAR / STRUCTURE

NOTE: USE AL AND H AS GIVEN ON PLAN IN FEET OR METERS

Add 20% shrinkage factor for estimating the total quantity.

12.7 SELECTION OF STANDARD ABUTMENT TYPES

From past experience and investigations the following types of abutments are generally most suitable and economical for the given conditions. Although piles are shown for each abutment type, depending on site material conditions spread footings may be utilized. The following chart is a recommended guide for abutment type selection.

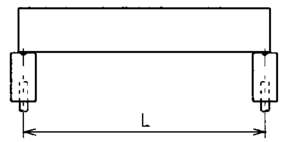
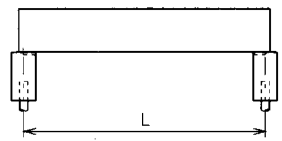
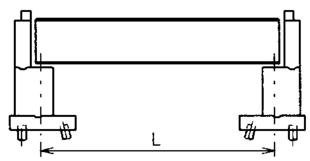
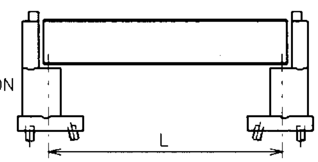
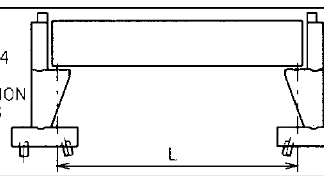
ABUTMENT ARRANGEMENTS L=Length of continuous superstructure between abutments	SUPERSTRUCTURES CONCRETE SLAB SPANS	 PRESTRESSED GIRDERS	 STEEL GIRDERS
	S=Skew, AL=Abutment Length		
(1) TYPE A1 WITH FIXED SEAT  TYPE A1 WITH FIXED SEAT	L ≤ 300' (90m) S ≤ 30° AL ≤ 50' (15m)	L ≤ 300' (90m) S ≤ 15° AL ≤ 50' (15m)	L ≤ 150' (45m) S ≤ 15° AL ≤ 50' (15m)
(2) TYPE A1 WITH SEMI-EXP. SEAT  TYPE A1 WITH SEMI-EXP. SEAT	a. L ≤ 300' (90m) S ≤ 30° AL > 50' (15m)	a. L ≤ 300' (90m) S ≤ 40°	a. L ≤ 200' (60m) S ≤40°
(3) TYPE A3 WITH FIXED BEARING  TYPE A3 WITH EXPANSION BEARING	NOT USED	NOT USED	L ≤ 200' (60m) S > 40°
(4) TYPE A3 WITH EXPANSION BEARING  TYPE A3 WITH EXPANSION BEARING	b. L > 300' (90m) with rigid Piers and S ≤ 30°	Exceeds above Criteria for (1) and (2) and (3)	L > 200' (60m)
(5) TYPE A4 WITH EXPANSION BEARING  TYPE A4 WITH EXPANSION BEARING	NOT USED	c. Based on Geometry and Economics	d. Based on Geometry and Economics

TABLE 12.1 ABUTMENT TYPES

TABLE 12.1 - Abutment Types (Footnotes)

a. Type A1 fixed abutments are not used when wing piles are required. The semi-expansion seat is used in order to accommodate superstructure movements and minimize cracking between the wings and body wall.

b Consider the flexibility of the piers when choosing these abutment types. Only one expansion bearing is needed if the structure is capable of expanding easily in one direction. With rigid piers, symmetry is important for getting equal expansion movements and minimizing the forces on substructures.

c. For two-span prestressed girder bridges, the sill abutment is more economical than a semi-retaining, if the maximum girder length is not exceeded. It also is usually more economical if the next girder size is required.

d. For two-span steel structures with long spans, the semi-retaining abutments may be more economical than sill abutments due to the shorter bridge lengths if a deeper girder is required.

12.8 ABUTMENT DESIGN LOADS

An abutment may be subjected to both horizontal and vertical loads from the superstructure. The number and spacing of the superstructure girders determine the number and location of the concentrated reactions that are resisted by the abutment.

Although the vertical and horizontal reactions from the superstructure represent more or less concentrated loads, they are commonly assumed to be distributed over the entire length of the front wall of the abutment. That is, the sum of the reactions, either horizontal or vertical, is divided by the length of the wall to obtain a load per unit length to be used in both the stability analysis and the structural design. This procedure is sufficiently exact for most design purposes. However, in the design of low abutments where the reactions from the superstructure are widely spaced, considerable judgment is exercised in the establishment of a reasonable width over which each reaction is distributed.

(1) Vertical Loads and Load Factors (LRFD)
Use a value of Ø = 1.00 for ductility, redundancy and operational importance.

A. Superstructure dead load - 1.25
B. Superstructure live load - 1.75
C. Approach slab dead load - 1.25
D. Approach slab live load - 1.75
E. Wheel load directly on abutment backwall. (1.75)

(2) Horizontal Loads and Load Factors (LRFD)

A. Superstructure wind load - 0.00

Superstructure wind loads in a transverse direction can be ignored.

B. AASHTO "Longitudinal Force" from live load - 1.75
C. Temperature and shrinkage - 1.20
D. Earth pressure - 1.35
E. 2 foot (600 mm) live load surcharge - 1.75

12.9 ABUTMENT BODY DETAILS

There are many different body sections that are utilized for each of the different abutment types. When designing these sections, it is inadvisable to use skimpy highly reinforced sections. It is better to use a lot of concrete and less steel, thus making parts rather massive and stiff. Adequate horizontal reinforcement and vertical contraction joints are essential to prevent cracking, especially when wing walls are poured monolithically with the abutment body.

The bottom of abutment bodies are normally constructed on a horizontal surface. However, abutments constructed this way may require one end of the body to be much higher than the opposite end due to the vertical geometrics of the bridge. This sometimes requires an extremely long and high wing wall. For these extreme cases the bottom of the abutment body is sloped.

The berm in front of the body is held level even though the body is sloped. A minimum distance of 1 foot (300 mm) between top of berm and top of beam seat is allowed. Minimum ground cover as shown in the standard is maintained.

Sloping the bottom of the body results in a longer bridge. This is usually more costly than holding the body level and using larger wings and beam seats. Sloping abutments are also more difficult to build. Good engineering judgment is the criteria to use when determining if the bottom of the abutment is level or sloped. Generally, if a standard wing wall design cannot be used, the bottom of the abutment body is sloped.

(1) Construction Joints

In a U-shaped abutment, with no joint between wing and body, traffic tends to compact the fill against the 3 sides of the abutment. When the temperature drops, the body concrete cannot shrink without tending to squeeze the warmer fill inside. The resistance of the fill usually exceeds the tensile or shearing strength of the body or wing and cracks result.

If contraction joints are not provided in long abutment bodies, nature usually creates them. To prevent uncontrolled cracking in the body or cracking at the body-wing joint, body pours are limited to a maximum of 50 feet.* Shear keys are provided in construction joints so that the center pour does not lose the beneficial stabilizing effect from the wings. The shear keys enable the end pours, with their counterfort action due to the attached wing, to provide additional stability to the center pour. Extend the bar steel through the joint.

In general, body construction joints are keyed to hold the parts in line. Water barriers are used to prevent leakage and staining. Steel girder superstructures generally permit the tiny movement at construction joints without cracking the concrete slab above on the girders. In the case of concrete slabs, prestressed concrete girder or T-beam construction, a crack will frequently develop in the deck above the abutment construction joint. The designer should consider this when locating the construction joint.

| *** LRFD specifications have a limit of 30 feet but WisDOT has not experienced significant problems with 50 feet. Expansion joints are required at 90 feet.**

(2) Beam Seats

Because of the roadway cross section slope or skewed abutments, it is necessary to provide beam seats of different elevations on the abutment. The tops of these beam seats are poured to exact elevation and made level except when elastomeric bearing pads are used and grades equal or exceed 1%. For this case make beam seat parallel to the bottom of girder or slab. Shrinkage and practical difficulties in obtaining good workmanship make it difficult to obtain the exact beam seat elevation.

When detailing abutments, the differences in elevations between adjacent beam seats is accomplished by stepping the top of the abutment or by the use of steel filler plates. For girders on steel bearings the abutment is stepped if the difference between adjacent girder elevations is greater than 1/2 inch (10 mm). Otherwise, steel fill plates are used.

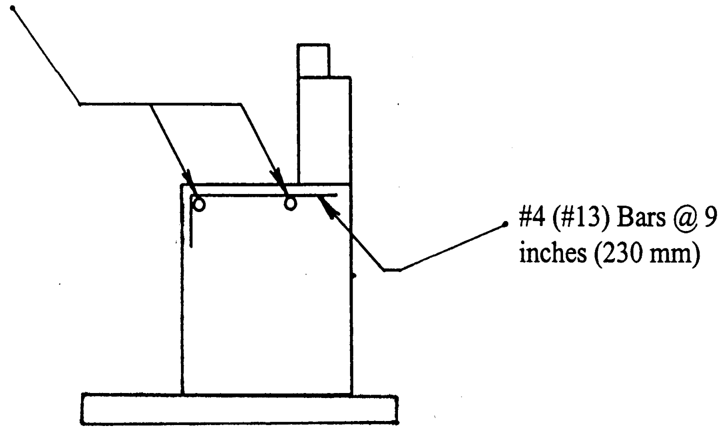
For girders on elastomeric bearing pads the abutment is stepped if the difference between adjacent girder elevations is greater than 1/4 inch (5 mm). If the difference is equal to or less than 1/4 inch (5 mm), both seats are detailed at the lower elevation of the two girder seats.

The tops of bearing seats are usually subjected to very large localized pressures under the bearings.

Additional reinforcement directly under the bearing is sometimes necessary to prevent the formation of visible cracks or possible spalling of concrete. This additional reinforcement is required for seats that are stepped 4” (100 mm) or more when the standard body reinforcing is not sufficient to prevent the possibility of this cracking or spalling. A grid of bars as shown in the sketch is usually used.

This grid is not effective in spreading loads. It cannot offer resistance to tensile forces except as there is deformation, and this may be when hair cracks have formed. It is designed primarily to hold the top corners and edges in place even if tiny cracks do occur.

#4 (#13) Bars Bend Down into
Body if Beam Seat Projects
more than 4 inches (100 mm) above adjacent
Beam Seat.



BODY SECTION
Showing Grid Detail in Bearing Seat

12.10 TIMBER ABUTMENTS

Timber Abutments consist of a single row of piling capped with concrete or timber and timber backed to retain the approach fill. The superstructure types are generally concrete slab or timber. Currently timber backed abutments exist on Town Roads and County Highways where the abutment height does not preclude the use of timber backing. They are not recommended for new bridges.

Piles in bents are designed for combined axial load and bending moments. For analysis, the assumption is made that the piles are supported at their tops and fixed 6 feet (2 meters) below stream bed or original ground line. For cast-in-place concrete piling, the concrete core is designed to carry the axial load. The bending stress is carried by the steel shell section. Due to the possibility of shell corrosion, steel reinforcement is placed in the concrete core equivalent to a 1/16 inch (2 mm) steel shell perimeter section loss. The reinforcement design is based on equal section moduli for the two conditions. Reinforcement details and bearing capacities are given on Standard 11.1. Pile spacing is generally limited to the practical span lengths for timber backing planks.

The requirements for tie rods and deadmen is a function of abutment height. Tie rods with deadmen on body piling are used when the height of "freestanding" piles are over 12 feet (3.5 meters) for timber piling and over 15 feet (4.5 meters) for cast-in-place concrete and steel "HP" piling. The "freestanding" length of a pile is measured from a stream bed or berm to grade. If possible, place all deadmen against undisturbed soil.

Commercial grade lumber as specified in AASHTO having a minimum allowable stress in bending of 1200 psi (8 MPa) is employed for timber backing planks. The minimum recommended nominal thickness and width of timber backing planks is 3 and 10 inches (75 and 255 mm) respectively; analysis computations are based on the dressed or finished sizes if nominal sizes are called for on the plans. Design computations can be used on the full nominal sizes if so stated on the Bridge Plans. For abutments constructed with cast-in-place concrete or steel "HP" piles the timber planking is attached with 60d common nails to timber nailing strips which are bolted to the piling.

12.11 BRIDGE APPROACH DESIGN AND CONSTRUCTION PRACTICES

While most bridge approaches are reasonably smooth and require a minimum of maintenance, there are rough-riding approaches with maintenance requirements. The bridge designer should be aware of design and construction practices that minimize bridge approach problems. Soils, design, construction and maintenance engineers are jointly responsible for efforts to eliminate rough bridge approaches.

An adequate investigation of the foundation site is important for bridge design and construction. The soils engineer, using tentative grades and foundation site information, can provide advice on the depth of material to be removed, special embankment foundation drainage, surcharge heights, waiting periods, construction rates, and the amount of post-construction settlement that can be anticipated. Some typical bridge approach problems are:

1. Settlement of pavement end of approach slab.

2. Uplift of approach slab at abutment caused from swelling soils or freezing.

3. Backfill settlement under flexible pavement or approach slab not adequately supported at the abutments.

4. Erosion due to water infiltration.

Most bridge approach problems can be minimized during design and construction by adequate consideration of:

1. Embankment height, material, and construction methods.

2. Subgrade, subbase and base material.

3. Drainage-runoff from bridge, surface drains and drainage channels.

4. Special approach slabs allowing for pavement expansion.

Post-construction consolidation of material within the embankment foundation is the main contributor to rough approaches. Soils which consist predominantly of sands and gravels, are least susceptible to consolidation and settlement. Soils with large amounts of shales, silts, and plastic clays are highly susceptible to consolidation.

The following construction measures can be used to stabilize foundation materials:

1. Consolidation of natural material. Allow sufficient time for consolidation under the load of the embankment. When site investigations indicate an excessive length of time is required, other courses of corrective action are available. Use of a surcharge fill is effective where the compressive stratum is relatively thin and

sufficient time is available for consolidation.

2. Complete or partial removal of material. This procedure is practical if the foundation depth is less than 15 feet (4.5 meters) and above the water table.

3. Lightweight embankment materials. Lightweight materials (fly ash, expanded shale, cinders) have been used with apparent success for abutment embankment construction to lessen the load on the foundation materials.

Abutment backfill practices that help to minimize either settlement or swell are: (1) use of select materials; (2) placement of relatively thin 4-6 inch (100-150 mm) layers; (3) strict control of moisture and density and; (4) installation of moisture barriers.

Highway engineers generally agree that the bridge abutment causes no more than 5 to 10 percent of the problem associated with bridge approaches. Proper drainage needs to be provided to prevent erosion of embankment or subgrade material that could cause settlement of the bridge approach. It is essential to provide for the removal of surface water that leaks into the area behind the abutment by using weepholes and/or drain tile, etc. Prevent any water infiltration between the approach slab and abutment body and wings.

Reinforced concrete approach slabs are the most effective means for controlling surface irregularities caused by settlement. It is also important to allow enough expansion movement between the approach slab and approach pavement to prevent horizontal thrust on the abutment.